

Small Wind Applications Guide—Accompaniment to Video



Photos: Colorado Governor's Office of Energy Management and Conservation, except as noted.

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Foreword

This project was conceptualized and formulated to demonstrate the feasibility and desirability of blending wind power with consistent power generation. In this case, OEMC wished to blend the wind power with biogas produced from hog manure, allowing for biogas to power a reciprocating engine and provide on-site power to the hog farm. The successful outcome of that effort is explained in a video. The following text further details the information on the video and fully illustrates how anyone can analyze and determine whether wind power can be beneficially and economically used on his or her property. The video is accessible, at no cost, from the OEMC website: www.state.co.us/oemc.

Introduction

Colorado has an abundance of traditional fuels such as oil, coal and natural gas, but it is also a state rich in renewable energy, especially wind (see map, last page).

For example, Colorado is ranked 11th in the nation for its wind resources. But this is not news to Coloradans, especially those working and living on the plains of Colorado. Colorado has three large-scale wind farms totaling over 225 Megawatts, including Colorado Green in Prowers County, which makes Colorado the nation's fifth largest producer of wind-powered electricity. Wind farms, however, are not the primary intent of this video as the object is to help individuals and small businesses learn what is involved in putting up small wind turbines; from as little as 35 kW up to 300 kW.

That said, some people might want to consider the idea of “community” generation; that does not mean that you have to consider a whole town. For example, if your ground is not ideal, how about your neighbor's? Can your turbine optimally be sited on better ground nearby where higher electrical production would offset any increased cost?

Sometimes, an option like this may help you satisfy local codes or improve safety issues.

To help understand what it takes to get from the observation that a strong, dependable wind is available on or near to your property to actually producing wind-powered electricity for your home or business, this video will take you on a virtual tour of a Colorado hog farm which has installed a 65 kW wind turbine to offset some of its electrical-use costs. This video will illustrate all the steps you must go through to put up a wind turbine and all things you must consider along the way, including your time and associated costs.

*“If the wind
blows strong
and long on
your property
are you a good
candidate for
harnessing the
wind?”*



EMS 65 kW wind turbine at Colorado Pork, LLC, near Lamar, CO.



Emick Ranch Exhibits Old Wind Turbines near Colorado Green Wind Farm, Lamar, CO



Steps for Small Wind

PHASE ONE: FEASIBILITY, ASSESSING SITE, ENERGY USAGE, FINANCIAL AND OTHER CONSIDERATIONS



STEP 1: Determine the reasons why wind power is being contemplated, as well as the risks and limitations of generating on-site power. Some reasons you may consider wind power are:

- To provide distributed generation power, i.e., power generated that is not a part of a grid, to a home or business.
- To produce power more cheaply than that purchased from the grid and thereby reduce on-site power costs.

- To increase production efficiency by employing combined heat and power (CHP) or combined heating, cooling and power (CCHP).
- To decrease some amount of pollution by using renewable fuels or increasing production efficiencies.
- To provide some self sufficiency.
- To lower your peak demand through better energy-use scenarios.
- To maximize your energy savings and minimize the size of your wind turbine needs, you should first consider implementing energy cost-saving features. This could be done in your building or residence to reduce your energy loads, including energy-saving devices bearing the Energy Star label, such as compact florescent lamps; double paned gas-filled windows with low emissivity coatings (e.g., low-e); exterior envelope insulation; and scheduling energy-intensive tasks/processes at off-peak times. For more energy saving tips, order the Energy Savers catalog at www.eere.energy.gov.

STEP 2: Measure the wind on your property, and determine the best location to make the measurements.

- To determine the best site, you must be sure that no buildings, structures, hills, trees, etc. impede the flow of wind. In general, your turbine should be 30 feet above anything within 300 feet of the turbine. For further information about the best location, contact OEMC, USDOE's Wind Powering America (WPA), America Wind Energy Association (AWEA) or a wind turbine manufacturer, among others.
- To measure wind, an anemometer is installed on a tower at a selected site where you believe offers the best opportunity for wind-power production.



Erecting anemometer towers, near Julesburg (above) and Aurora (below)





Anemometer on 20m tower

- Anemometers are devices that measure wind parameters, such as speed, variation, direction and consistency, and collect data to determine the feasibility of capturing sufficient wind to produce energy.
- OEMC has a Wind Anemometer Loan Program which provides a tower and anemometer to Colorado citizens and businesses. To learn more about this program, visit www.state.co.us/oemc. Anemometers and towers are also available from Western Area Power Administration and can be purchased from suppliers; one such supplier is NRG.
- OEMC's anemometers are placed on 20m (66 feet) or 33m (98 feet) towers. These are appropriate heights to measure wind potential for small wind applications. (We also have one 50m, 164 feet, tower that can be borrowed to assess wind potential for large-scale applications; in case wind assessment using the smaller towers demonstrated considerable opportunities for greater production at the site.) The wind is collected over a period of one year and the data is stored on a data plug.

STEP 3: Evaluate the wind data collected.

- The data plugs from the anemometers are collected by OEMC personnel or the site owners and the plugs are sent by OEMC personnel to universities contracted by OEMC to analyze the contained data.
- OEMC uses the universities expertise to evaluate and graph the data and summarize the characteristics of the wind.



Data loggers for anemometers



STEP 4: Make a decision to proceed based on wind data evaluation.

- In general, your location should have average wind speeds of at least 11mph. From the developed summary, the wind class provides the best indicator of site value; the wind class should be at least class three, or in some applications, a very high class two to make the site a good or sufficient candidate for a wind turbine installation. Also, if the wind often exceeds speeds such as 70mph, it might be too risky to place a wind turbine on the site.
- If the data collected indicates the site is generally good for wind energy development, then the data must be observed closely to note if there are months or times of day that do not offer reasonable power production coincident with power needs of the facility.
- It must also be considered whether the expected power production is sufficient to warrant the investment or time to plan and construct the wind power application.

STEP 5: Size a wind turbine.

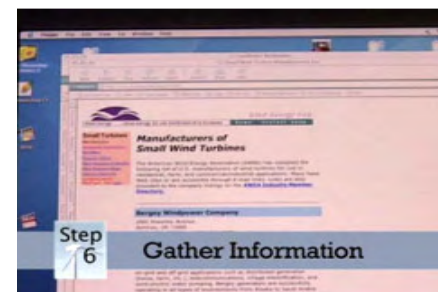
- You can size your turbine by first determining how much of your facility's load you want the turbine to be able to carry and/or, if the opportunity is available to you, how much energy you might want to sell to your utility.
- Some of the things you'll want to consider are: the amount of energy you use in an existing facility or the amount you need to supply a planned facility; the amount of energy you want to supplant; an



amount you want to sell; your ability to handle repairs or replacements of the wind equipment; the physical space you have on which to place the device; and the expected cost of construction, electrical interconnections, operation and maintenance, insurance requirements, and local code and utility requirements.

STEP 6: Gather information from wind turbine suppliers, both remanufactures and manufacturers.

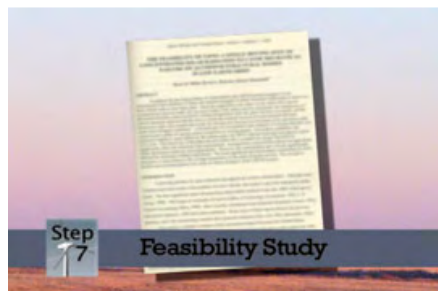
- This is very important and you should put adequate time into this area. AWEA recently published an article by Mick Sagrillo that addresses a part of this issue—fraud in the industry and how to reduce the chance of being a victim. Make sure the supplier you deal with is a reputable one.
- Using the sizing decisions you reached in step 5, ask the suppliers what is available to meet your energy needs and the general costs of purchasing and construction. Also, ask the suppliers to tell you the capacity factor of any of the turbines which might meet your needs. The capacity factor is based on the characteristics of the turbine and the wind resource in which it is placed. (Be sure to provide the supplier with your site's measured wind resource.)
- The capacity factor is computed by comparing actual production to theoretical production. The higher the resulting number, the greater will be the turbine's yearly electrical power output. For example, a 65 kW turbine could theoretically produce 569,400 kWh per year. That is, $65\text{kWh} \times 24 \text{ hours} \times 365 \text{ days} = 569,400 \text{ kWh}$, the theoretical production. However, let's say the 65kW turbine actually produces only 170,000 kWh, then the capacity factor is 29.9%. The 29.9%, in this example, is found by dividing the actual capacity of our 65 kW turbine (170,000 kWh) by the theoretical capacity (569,400 kWh).



- The Internet is a good place to look for wind turbine suppliers, along with contacting wind energy agencies and organizations.
- The Lamar hog farm's remanufactured wind turbine was procured from Energy Maintenance Service (EMS) of Gary, South Dakota. OEMC mentions this only as fact and does not endorse any supplier of equipment or service. Of note, the primary value of good used equipment in this context is that it is economic even on marginal wind sites due to lower costs. Also, the durability of a good used turbine is likely greater than a new one.
- The 65kW wind turbine was selected because of many of the previous issues; to demonstrate the actual process of procuring, installing and commissioning a wind turbine at a rural business facility; and to promulgate the outcome to citizens and businesses of Colorado so that others would understand what is involved in the undertaking. The wind data gathered from the anemometer placed at Colorado Pork for over one year indicated sufficient and reliable wind existed at the spot; and using a remanufactured windmill appeared to be an economical and reliable purchase.

STEP 7: Prepare a feasibility study.

- If you decide on a specific sized turbine and a supplier, know the complete/estimated costs through installation and commissioning, establish that you don't need additional funding and have confidence in O&M costs, then you likely don't need a feasibility study.
- If you are unsure of the above considerations or you need additional funding, it would be wise to contact AWEA, DOE's Wind Powering America, or other wind experts and enlist their help through a contract to develop a feasibility study.



- Be sure your feasibility study fully covers all contingencies, such as including all the trades and contractors necessary to do the work and understanding their costs and general timelines; awareness of all potential construction problems; code and permit issues, etc.

STEP 8: Secure financing.

- For this project, OEMC provided \$85,000 in funding for the wind turbine and its full installation and commissioning; Colorado Pork provided the land and insurance; and DOE's Wind Powering America provided funding for production and filming of the video.
- Colorado Pork, the owner of the wind turbine, which is expected to last 20+ years, is responsible for ongoing maintenance outside of the warranty coverage.
- The calculated payback for this project has been estimated to be 8 to 12 years.
- A site owner must determine his or her own financing and ability to secure it. To do so, contact the usual groups, like AWEA or DOE's Wind Powering America to gather information which provides case studies including financing information, and then contact your local bank or other financiers.





PHASE TWO: TURBINE INSTALLATION AND NECESSARY PREPARATION

STEP 9: Find contractors, if necessary, to facilitate installation for the manufacturer or to do the various subtasks not covered under the purchase price.

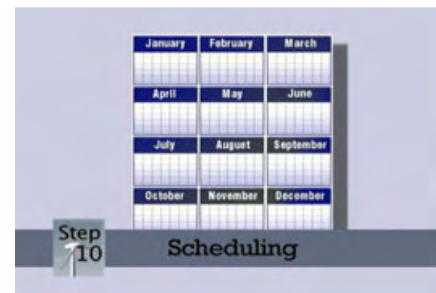
- Depending on the level of direct involvement by you or your employees in the installation of a wind turbine, you will either have to contract with some or all of the contractor types who will be involved.
- The installation will involve, at a minimum, an electrician; an electrical engineer; a crane operator (unless the tower and turbine can be placed with ropes/cables and leverage devices) and crane; someone to do a core sample; a lab to do the core sample analysis, if the core sample company does not also do analyses; a concrete



company and a concrete contractor, if the concrete company does not also do concrete pad installations; and, maybe, a general contractor to oversee the full project, if you or the turbine supplier do not fulfill that responsibility.

STEP 10: Set Timetables

- Set timetables for delivery of equipment and installation milestones; secure insurance against any personal liabilities and make sure you keep your utility apprised of your time schedule



STEP 11: Determine your responsibilities to the project and warranty coverage.

- Carefully read any warranties/guarantees provided by suppliers and contractors and be prepared to fulfill your obligations so as not to hold up installation or, after installation and commissioning is complete, bring the unit back up after a shutdown (while fully assessing whose responsibility it is to pay for and provide logistics for shutdowns that occur during warranty).



STEP 12: Meet with code officials and secure permits from appropriate agencies and meet with utility providers to establish interconnection and safety requirements.



- For the wind turbine installation at Colorado Pork, it was Colorado Pork and OEMC who had to resolve all siting and permitting issues. In this case, and likely for most cases, the land/business owner will need to contact code jurisdictions and the utility provider to ascertain all installation requirements and to obtain all necessary documents before an installer begins the installation. So, be sure to fill out all the paperwork supplied by the code officials, learn about what your utility will require from you and provide full access to any current generation devices, connections and meters located at your facility.

STEP 13: Conducting core sample drilling and soil analysis.

- Clearly mark the spot where your concrete pad will be located.
- Have a soil core sample taken of the spot where the pad for your turbine will be located. Be sure to inform the contractor on where to enter your land and adequately mark the route to take to reach the sample spot.
- If the contractor will not be doing the soil sample analysis, provide the contractor with complete instructions on how and where to send the core. (As part of the cost of the turbine and its package, the analysis may be done by the turbine supplier. That was the arrangement for the Colorado Pork installation.)

STEP 14: Construct the turbine's pad

- After the soil sample analysis report has been received, be sure the analysis is given to your general contractor or the turbine installers so they

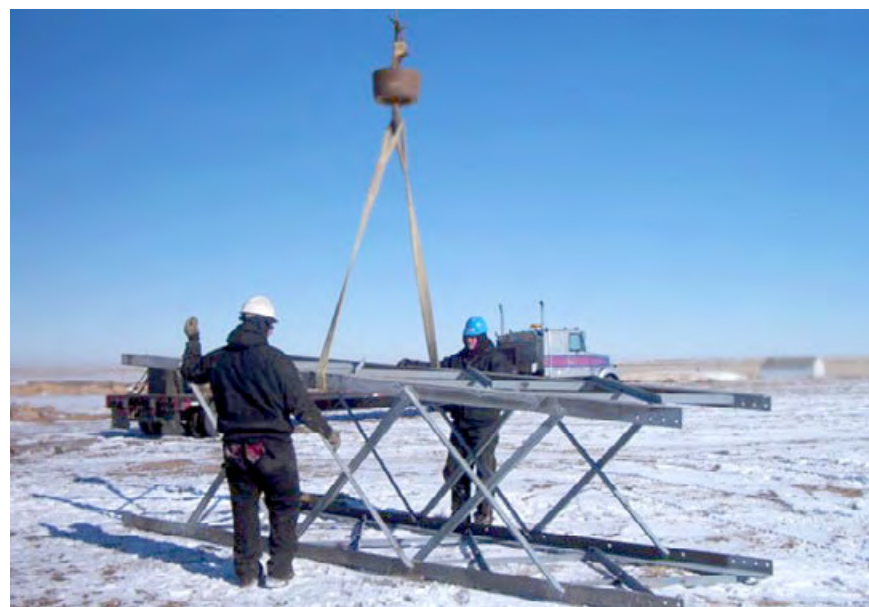


can design the pad. In turn, they will indicate what specific constituents must be mixed into the concrete; how deep, wide and of what configuration the pad must be; what the exact dimensions must be for the pad; and how many pours must be made in order for the pad to be as durable and long-lasting as possible.

- Make sure the pad site is still well marked. Be sure to inform the contractor on where to enter your land and the route to take to reach the area where the pad will be built.

STEP 15: Erect the tower and turbine.

- If the turbine supplier is not responsible for erecting the unit, contract to have it done.



Raising the tower for the EMS 65kW turbine at Colorado Pork, LLC



- If the turbine supplier is putting up the unit, supply names of contractors in your area who have the necessary equipment and experience to do the work.
- In any case, you will have to be able to accommodate a large crane and its truck in reaching the pad. This feat may require coordination with utility crews and others to get under lines of many types or may require coordination with police or others to clear traffic. You must also assure that trees and buildings on your property will not interfere with ingress or egress. You must prepare well ahead of time to accomplish these logistics in order not to delay the process or to increase your costs.

Raising the nacelle (left) and wind turbine blades (below), Colorado Pork, LLC



STEP 16: Trench and lay electrical and telecommunication cable/wire between the turbine and the generation location.

- Contract to trench and lay wiring, if the turbine supplier has not included this task in the turbine cost. If the price has been included, supply names, if necessary, of local contractors who can do the job for the turbine supplier.
- Locate and clearly mark the shortest possible route for the trench; taking care to know what utility lines and other buried items exist along the route. Be sure to list, for the contractor, any known buried items that may lie along the route.
- Supply for the company doing the work, if necessary per your agreement with the turbine supplier, any materials required to do the job; this could include the cabling and maybe the trenching machine.



STEP 17: Set up or facilitate the electrical connection.

- Since there is no reason to wait until the equipment arrives to do the electrical interconnect, it would be prudent to complete it before the equipment shows up. Too often, turbine buyers do not understand that the project can proceed at a faster pace and that erection crews can avoid downtime and have the unit commissioned more quickly. Keep in mind that downtime can be very costly to both you and the installer.



- First, the site owner or manager must discuss the interconnection of the small wind turbine with the local utility. This is necessary for safety reasons and to protect the turbine and other interconnected devices. The electrical engineer and electrician must be in on those discussions.

- Southeast Colorado Power Association (SECPA) is the local utility for Colorado Pork. They have been excellent to work with, as the farm already has an anaerobic digester that supplies methane gas to produce electrical power for the farm and they were very much involved with the installation of the wind turbine.

- The wind turbine is an example of blending onsite generation. That is, since the windmill does not constantly supply electricity, the electricity that it does supply is “blended” with electricity supplied constantly by the anaerobic digester which is located at Colorado Pork. The wind turbine is electrically connected to produce power that is only consumed on the farm. The wind turbine has been wired so that it will shut down and be isolated from the utility lines if any power irregularities, such as power spikes, are created that fall within a specific range initially set by the turbine manufacturer or supplier.

STEP 18: The grid is required to operate the turbine and keep its oil warm.

- A wind turbine must have power, from the grid or some other source, to be able to be operated and to keep its oil warm when the turbine is not operating. If the oil is too cold, and therefore too viscous, then the turbine will not be able to turn properly.
- When the grid is down, your wind turbine will be down.



- In the case of the hog farm wind turbine, should the grid go down, a large 375kW internal combustion generator automatically comes on line to assure that all the farm's systems are running and the hogs have adequate heating or cooling to keep them alive. With that generator, the hog farm wind turbine can continue to run and continue to reduce the overall cost of electricity.

STEP 19: Commission the wind turbine and its systems.

- When the turbine has been fully connected to provide power to your facility and receive power from the grid, you must have it commissioned. Commissioning is the process by which a system is powered up and all the functions of the system are tested to be sure that everything is fully operational within all prescribed ranges and functions. If everything does not operate as specified, the installer/contractor must make all necessary corrections before turning the system over to the owner/operator. When that turnover occurs, the arrangement between the installer/contractor and owner/operator enters the warranty period. So, be sure you fully believe the system checks out before accepting it.



PHASE THREE: ONGOING MAINTENANCE AND MEASURING ACTUAL TURBINE PERFORMANCE

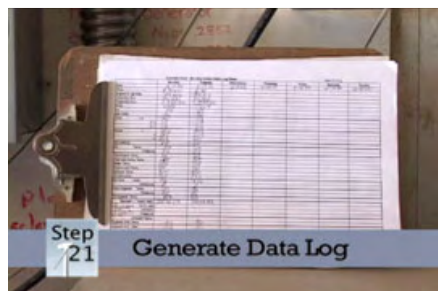
STEP 20: Train on-site workers to handle maintenance or to spot maintenance problems and transmit problem information to contracted maintenance workers.

- Likely, the arrangement between you and the turbine supplier includes some training provision; either contract-included or available at extra cost. If training is not included, it is highly recommended that you have it provided.
- Since, for example, electrical spikes can occur, you or a contract employee should be prepared to adjust the parameters that determine turbine shutdown, should excessive shutdowns occur. It is also likely, particularly at remote sites, that you or your contract employee might need to take care of items covered by warranty, which would of course be paid for under the warranty.



- In any case, people on the site should note, several times a day, whether the turbine is running and then either check the fault indicator and fix the problem or contact the person who is charged with doing repairs and provide that person with the fault number displayed.
- It is recommended that the installation include a modem and phone line to the turbine so that the installer, you, or someone you designate, is able to contact the modem for information about the turbine's operation. The modem will give you data which can be used for moment-by-moment status or for problem diagnosis.

STEP 21: Generate a data log and compare actual performance with expected performance.



- Use your modem and programs recommended by your turbine supplier to collect data important to you, such as uptime, downtime, faults displayed and times-of-day, month and year when your turbine is producing the greatest and least amount of power.
- Use the data collected to forecast future income and outlay and to predict maintenance schedules. It is also useful to put together a presentation or some handout that can be used to provide information to others considering wind-power generation or wanting to understand more about this renewable energy option.

CONCLUSION:

Small wind power is often an economical, practical and renewable solution for meeting our growing energy needs. By generating power on-site, site owners are able to reduce their overall and peak energy costs through the use of a clean energy source.

Successful projects require diligence, capital and resource investment on the part of the project owner. The guidelines and information shared in this video are intended to assist small wind developers in this process and to ensure that their endeavor will be successful.

OEMC and our partners welcome your comments and questions about this video or its accompanying standalone text. To contact us, please email our office: oemc@state.co.us.

CREDITS:

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Additional Thanks for the Support in this Small Wind Application Guide:

Colorado Governor's Office of Energy Management and Conservation:
Megan Castle, Olga Erlich, Joe Lambert, Ed Lewis

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U.S. Department of Energy's Wind Powering America Program: Steve Palomo

Montana Marginal Energy: Dave Healow

Southeast Colorado Power Association: Jack Wolfe

Useful Websites:

American Wind Energy Association: www.awea.org

Colorado Governor's Office of Energy Management and Conservation:
www.state.co.us/oemc

Energy Maintenance Service, LLC: www.energymys.com

U.S. Department of Energy's National Renewable Energy Laboratory's Wind Test Center: <http://www.nrel.gov/wind/>

U.S. Department of Energy's Wind Powering America Program:

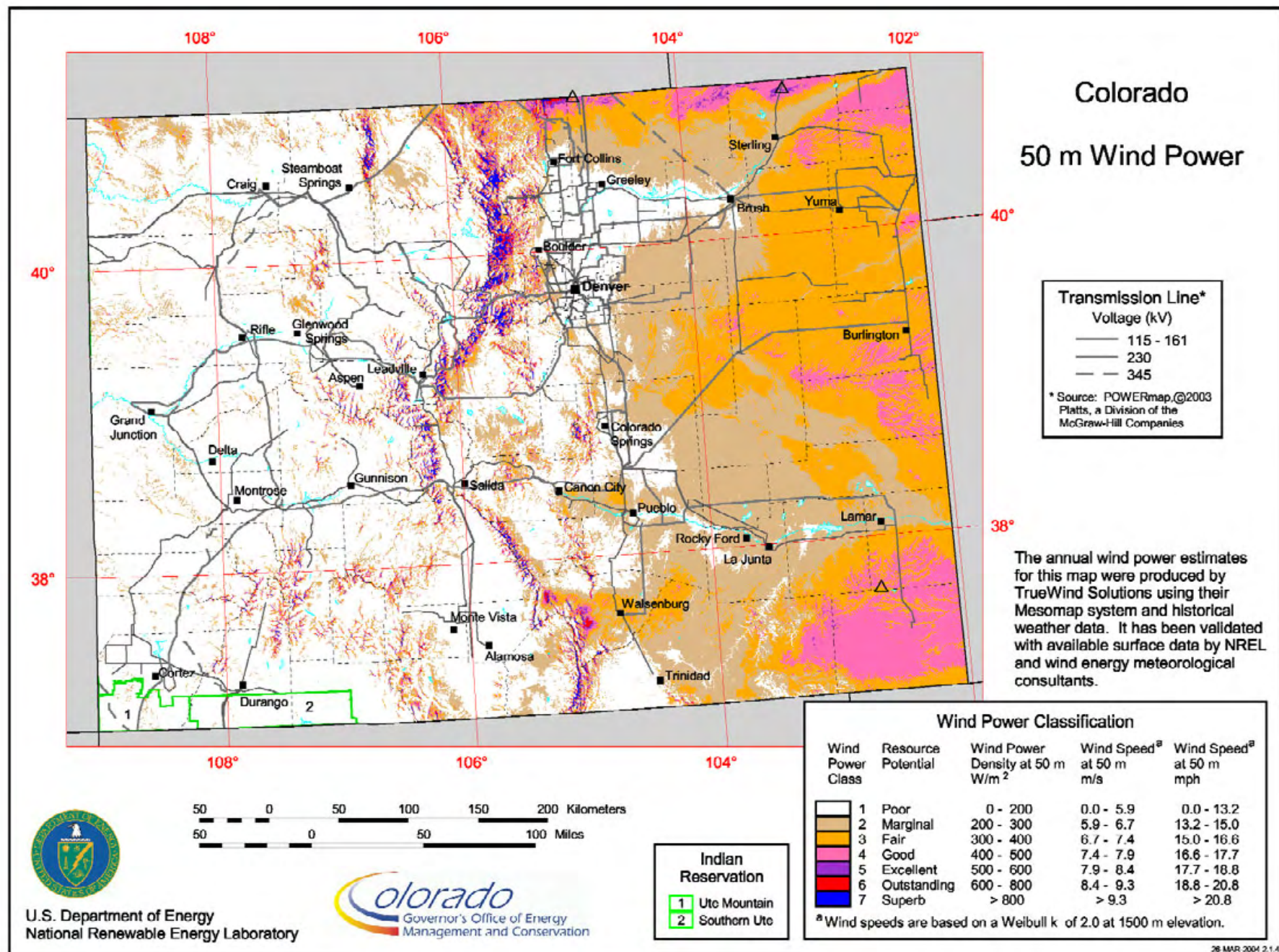
<http://www.eere.energy.gov/windandhydro/windpoweringamerica/>

Southeast Colorado Power Association: www.secpa.com

Western Area Power Administration: www.wapa.gov



Colorado Pork, LLC, near Lamar, CO



Colorado Wind Map, DOE's Wind Powering America and OEMC